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Review Article

Water, Sanitation, and Hygiene (WASH) Gaps as Drivers of Antimicrobial Resistance in Sub-Saharan Africa: A One Health Perspective

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Abstract:
Antimicrobial resistance (AMR) is a growing global threat, and sub-Saharan Africa (SSA) bears a disproportionate share of this burden. This narrative review examines how deficiencies in water, sanitation, and hygiene (WASH) contribute to AMR in SSA. It draws on peer-reviewed literature, institutional reports, and regional policy documents published between 2015 and 2025. Sources were identified through databases such as PubMed, Google Scholar, and WHO/UN databases using combinations of keywords including 'AMR', 'WASH', 'Sub-Saharan Africa', and 'One Health'. We survey recent literature on the regional AMR problem, the role of inadequate WASH in propagating resistant infections among humans, animals, and the environment, and the relevance of a One Health approach. Key themes include the high AMR mortality in Africa, the persistence of antibiotic residues and pathogens in poorly managed water and sanitation systems, and how poverty-related WASH gaps drive frequent infections that require antibiotics. Evidence suggests that unsafe water and sanitation facilitate the environmental circulation of resistant bacteria and genes. The One Health framework is highlighted as essential for addressing these links, since AMR crosses human, animal, and ecological domains. We conclude that improving WASH infrastructure and practices, alongside integrated AMR strategies, is critical to curb resistance in the region. Focusing on WASH under a One Health perspective can reveal overlooked pathways of AMR spread and inform targeted interventions in SSA.

Keywords: Antimicrobial resistance; WASH; One Health; Sub-Saharan Africa; Infection Prevention; Environmental Health; AMR Policy

Introduction

Antimicrobial resistance (AMR) is a rapidly rising global health crisis. WHO emphasizes that AMR already causes disproportionately high mortality in low- and middle-income countries due to heavy infectious disease burdens and limited resources (1). A recent report indicates that the African region has the highest global mortality rate from antimicrobial resistance, with 27.3 deaths per 100,000 population (2). These findings underscore that sub-Saharan Africa (SSA) is particularly hard-hit by drug-resistant infections, which compound existing health challenges. This is often attributed to infrastructural deficits in water, sanitation, and hygiene, and is further embedded in broader structural vulnerabilities (3). Weak governance, under-resourced health systems, and inadequate regulatory enforcement hinder the translation of policies into effective action (4). Limited diagnostic and laboratory capacity prevents early detection of resistant infections, while cultural practices such as open defecation, reliance on informal food markets, and indiscriminate use of antimicrobials in livestock production amplify exposure pathways (5).

Water, sanitation, and hygiene (WASH) interventions are foundational but often neglected measures for infection prevention and AMR mitigation (5). The World Health Organization explicitly identifies improvements in water, sanitation, and hygiene, as well as wastewater management, as “critical elements of preventing infections and reducing the spread of AMR.” (5). Conversely, inadequate WASH enables resistant bacteria and antibiotic residues to persist and spread through contaminated environments (6). Accordingly, one analysis notes that poor sanitation and a lack of safe water in Africa make infection avoidance extremely difficult, thereby compounding the transmission of AMR (7). In practice, the lack of clean water and sanitation facilities means that many infections go unchecked or require antibiotic treatment, creating selective pressure for resistance (7, 8).

SSA’s vulnerability to AMR arises not only from WASH gaps but also from interrelated socio-economic factors. Many communities lack reliable access to safe water, improved sanitation, and hygiene services, driving a high incidence of preventable infections (e.g., diarrheal diseases, typhoid, cholera) that often require antibiotics (9, 10). Crowded living conditions and close contact with livestock and wildlife further accelerate the spread of resistant pathogens (11). For instance, poor community sanitation has been linked to the transmission of bacteria resistant to virtually all available antibiotics (11-14). Meanwhile, limited healthcare and laboratory infrastructure mean that only about 1.3% of laboratories in 14 African countries can perform routine bacterial culture for AMR testing, which means that resistance often remains undetected and untreated (15, 16). These socio-economic and infrastructural vulnerabilities allow AMR to proliferate in SSA, where WASH conditions are suboptimal (6).

Addressing these challenges requires a One Health perspective that integrates human, animal, and environmental health. Global frameworks such as the Tripartite AMR Workplan and the One Health Joint Plan of Action (2022–2026) emphasize the alignment of antimicrobial stewardship, infection prevention, and WASH interventions across all three sectors. These frameworks offer practical guidance for cross-sector collaboration, acknowledging that AMR arises at the intersection of healthcare, agriculture, and environmental management (17, 18). In the context of WASH, this integration means aligning antimicrobial stewardship and infection prevention and control (IPC) with improvements in water and sanitation systems, wastewater management, and veterinary hygiene practices (7, 13).

From a One Health perspective, WASH deficiencies act as a common conduit linking human, animal, and environmental health. In the human sector, unsafe water and poor sanitation directly increase infection incidence, leading to greater antibiotic use and selective pressure for resistance (18). In the animal sector, lack of clean water for livestock and unhygienic waste disposal facilitates the spread of resistant organisms into food products and local water bodies (17). In the environmental sector, untreated sewage and agricultural runoff enrich soil and aquatic systems with resistant bacteria and antimicrobial residues, creating long-term reservoirs of resistance (19). These domains are interdependent. Resistant bacteria from the environment re-enter food chains, zoonotic pathogens transmit from animals to humans, and human waste contributes back into environmental reservoirs. Such feedback loops demonstrate that WASH gaps are not isolated human health challenges but systemic drivers of cross-sectoral AMR transmission (20).

This narrative review aims to critically examine the role of WASH deficiencies as drivers of AMR in SSA through the lens of the One Health approach. Our scope is grounded in the recognition that AMR, as a cross-sectoral challenge, cannot be effectively addressed through medical interventions alone. We integrate evidence from human health, veterinary, and environmental domains to illuminate how inadequate WASH infrastructure facilitates the emergence, persistence, and spread of resistant pathogens. In doing so, we align our analysis with the WHO Global Action Plan on AMR and related international frameworks that explicitly identify WASH as a cornerstone of AMR prevention. By synthesizing region-specific data and policy insights, we aim to identify actionable strategies that bridge the gap between AMR control and WASH investment, aligning with the *WHO Global Action Plan on AMR* (21) and the *One Health Joint Plan of Action 2022–2026* (18), offering a pragmatic roadmap for policymakers, researchers, and development partners in SSA.

Methodology

This study is a narrative review synthesizing recent evidence on the role of water, sanitation, and hygiene (WASH) in antimicrobial resistance (AMR) mitigation within a One Health framework in SSA.

Search Strategy

We searched peer-reviewed literature, institutional reports, and policy documents published between January 2015 and January 2025 to ensure contemporary relevance. Electronic databases included PubMed, Google Scholar, and Scopus, supplemented by grey literature from WHO, FAO, Africa CDC, and relevant national ministries.

The primary search terms and Boolean operators were:

- ("antimicrobial resistance" OR "AMR") AND ("water sanitation hygiene" OR "WASH") AND ("sub-Saharan Africa" OR "SSA")
- ("One Health") AND ("antimicrobial resistance" OR "antibiotic resistance") AND ("Africa" OR "low- and middle-income countries")
- ("environmental contamination" OR "wastewater") AND ("antibiotic residues" OR "resistant bacteria")

Reference lists of included articles were also manually screened to identify additional relevant studies. Our search retrieved 612 records. After removing duplicates and applying screening and eligibility criteria, 47 studies were included in the final synthesis (Table 1).

Inclusion Criteria

We included sources that met the following criteria:

1. Geographical relevance: Focus on SSA or present disaggregated SSA-specific data.
2. Topical relevance: Address WASH factors, AMR burden, One Health approaches, or cross-sector interventions.
3. Publication type: Peer-reviewed research articles, systematic reviews, narrative reviews, surveillance reports, and technical guidelines.
4. Timeframe: Published between January 2015 and January 2025.
5. Language: Available in English.

Grey literature was considered only if it originated from authoritative institutional sources (e.g., WHO, FAO, Africa CDC, national ministries of health or environment). To ensure reliability, these documents were appraised based on institutional credibility, transparency of data sources, and consistency with peer-reviewed evidence. Reports lacking methodological detail or clear attribution of data were excluded.

Exclusion Criteria

Sources were excluded if they:

- Focused exclusively on high-income countries without SSA relevance.
- Addressed AMR or WASH in isolation without discussing potential linkages.
- Were conference abstracts, opinion pieces, or non-substantive commentaries lacking primary or secondary evidence.

Data Extraction and Synthesis

For each included source, we extracted:

- Study type (e.g., observational, experimental, review, policy analysis).
- Geographic focus (country/region).
- WASH-related factors (e.g., water quality, sanitation coverage, hygiene practices, wastewater management).
- AMR outcomes (e.g., prevalence of resistant pathogens, antibiotic residue levels, surveillance findings).
- One Health relevance (e.g., cross-sector interventions, zoonotic transmission, environmental reservoirs).

Findings were organized thematically into:

1. Antimicrobial Resistance in SSA

2. WASH Infrastructure and AMR Transmission Pathways
3. One Health Approach
4. Policy and Implementation Challenges
5. Strategies and Recommendations

Given the scope of a narrative review, no formal meta-analysis was conducted. Instead, we synthesized qualitative and quantitative findings to identify cross-cutting themes and knowledge gaps.

Table 1. Summary of Literature Screening and Selection

Stage of Screening	Number of Records	Notes/Reasons for Exclusion
Records identified through database search	612	PubMed, Scopus, Google Scholar
Records after duplicates removed	500	112 duplicates removed
Records screened (title/abstract)	500	-
Records excluded	418	Not relevant to WASH–AMR link or SSA focus
Full-text articles assessed for eligibility	82	-
Full-text articles excluded	32	High-income countries; not WASH–AMR; opinion pieces
Studies included in the synthesis	50	Peer-reviewed articles, reviews, policy documents, technical reports

Antimicrobial Resistance in SSA

AMR poses a severe and escalating public health threat in SSA, where it undermines efforts to control infectious diseases, increases mortality, and strains fragile healthcare systems. The region experiences a disproportionately high burden of AMR, with over 27 deaths per 100,000 population attributable to drug-resistant infections, higher than in any other region globally (2). This burden is compounded by frequent outbreaks of bacterial infections, including typhoid, tuberculosis, and pneumonia, which are often treated empirically due to weak laboratory services and poor access to diagnostics (22).

Key drivers of AMR in SSA include the overuse and misuse of antimicrobials in human medicine, agriculture, and animal husbandry. Antibiotics are frequently sold without prescription, contributing to irrational self-medication and incomplete treatment courses (3). A multi-country survey reported that up to 60% of antibiotic consumption in SSA occurs without any medical supervision (23). In livestock production, antibiotics are often used not only for therapeutic purposes but also for growth promotion, further accelerating resistance transmission between animals and humans through food, water, and soil pathways (14, 24).

Surveillance of AMR remains limited across the continent. A 2023 WHO report found that less than 40% of African countries have national AMR surveillance systems aligned with the Global Antimicrobial Resistance Surveillance System (GLASS), and only a few have fully functioning reference laboratories (25). In many settings, healthcare facilities lack the capacity for bacterial culture, antimicrobial susceptibility testing, and resistance gene identification (5, 7). This contributes to delays in treatment, reliance on broad-spectrum antibiotics, and underreporting of resistance patterns.

Health system limitations further exacerbate the AMR crisis. Inadequate infection prevention and control (IPC) practices, insufficient health worker training, and a lack of essential medicines contribute to high rates of hospital-acquired infections (26). Additionally, limited public awareness and health literacy regarding AMR, especially in rural and underserved communities, hinder appropriate antibiotic use and adherence to treatment regimens (22).

Together, these factors create a feedback loop, poor regulation and weak surveillance fuel inappropriate antibiotic use, which in turn drives resistance, which then leads to more difficult-to-treat infections and increased mortality (23). In SSA, this cycle is particularly acute due to infrastructural gaps and socio-economic vulnerabilities (7). Addressing AMR in the region, therefore, requires not only antimicrobial stewardship but also broader structural reforms, including improved sanitation, education, and healthcare delivery systems (6).

WASH Infrastructure and AMR Transmission Pathways

The relationship between WASH and AMR is increasingly recognized as both a driver and a contributor to the AMR crisis. Inadequate WASH systems facilitate the emergence, persistence, and spread of resistant microorganisms in community, clinical, and agricultural settings (6, 27). This is particularly acute in SSA, where significant infrastructural deficits exist. The lack of access to safe water, appropriate sanitation, and basic hygiene practices not only increases the prevalence of infectious diseases but also leads to increased reliance on antimicrobials, often without regulation, thereby escalating resistance rates (25).

To illustrate the interconnected pathways of AMR transmission and potential intervention points, we developed a conceptual model (Figure 1) based on the WHO and One Health Joint Plan of Action frameworks. The model is adapted from the *One Health Joint Plan of Action* and the *WHO Tricycle Protocol* to visualize the flow of AMR between humans, animals, and the environment, and the role of WASH in interrupting these pathways (28).

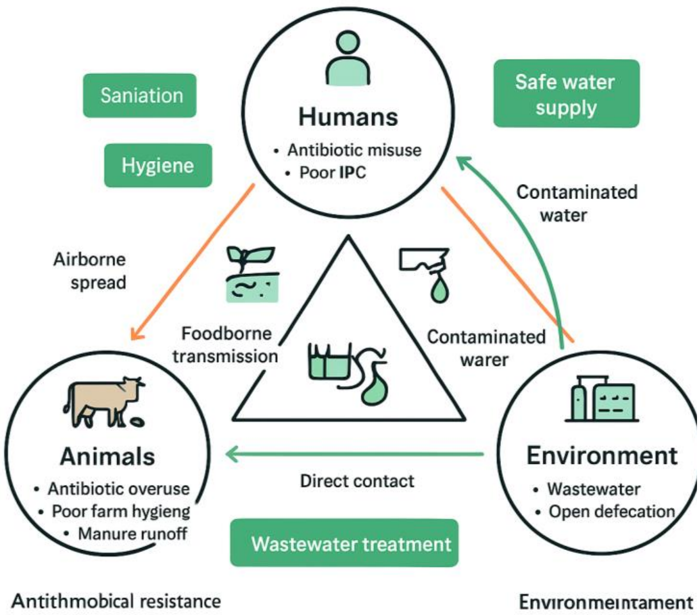

Figure 1. *Conceptual model of antimicrobial resistance (AMR) transmission pathways and intervention points under a One Health–WASH framework in SSA (28).*

WASH deficiencies create reinforcing cycles of antimicrobial resistance. Antibiotic misuse in humans, overuse in animals, and environmental contamination with waste and residues sustain resistant bacteria that move across sectors. Bidirectional feedback loops (arrows) illustrate the cyclical nature of AMR transmission. Interventions such as sanitation, hygiene, safe water supply, and wastewater treatment represent critical leverage points for interrupting these loops.

One of the primary transmission pathways involves environmental contamination through human and animal waste (12). In SSA, open defecation remains widespread, especially in rural and peri-urban areas (1, 12). According to UNICEF (2021), over 200 million people in the region still practice open defecation (19). This allows fecal matter, potentially containing resistant bacteria or antibiotic residues, to enter surface water sources, groundwater, and agricultural soil.

Recent empirical studies in SSA demonstrate the presence of multidrug-resistant (MDR) and extended-spectrum β-lactamase (ESBL)-producing *Escherichia coli* in both drinking and environmental water sources (29). In Southwest Nigeria, surface water contained ESBL-producing E. coli that harbored blaCTX-M genes and showed resistance to multiple antibiotic classes (30). Similarly, in Uyo, Nigeria, studies of clinical and household tap water detected MDR Enterobacteriaceae, including E. coli, with high rates of ESBL, AmpC, and metallo-β-lactamase co-producers, and frequent blaTEM, blaSHV, and blaCTX-M gene carriage (31). Meta-analyses covering broader regions of Africa reveal that approximately 50.7% of E. coli isolates from water samples are MDR, with substantial resistance to commonly used antibiotics such as ciprofloxacin and ampicillin (32). These findings are consistent with the *WHO Tricycle Project* pilot studies, which have demonstrated that ESBL-producing E. coli is a reliable integrated indicator of AMR across humans, animals, and the environment, and have documented its presence in water sources in Madagascar, Tanzania, and Nigeria (33, 34).

Study (Country, Year)	Sample Type	MDR/ESBL Prevalence	Key Resistance Genes Detected
Bisi-Johnson et al., Nigeria (2023)	Freshwater surface sources	ESBL-*E. coli* detected (multi-antibiotic resistance)	bla*CTX-M*
Akinjogunla et al., Uyo, Nigeria (2023)	Clinical & household tap water	High MDR; ~36.5% ESBL; AmpC & MBL producers also common (~28–62%)	bla*TEM*, bla*SHV*, bla*CTX-M*
Meta-analysis (Africa, studies 2000–2021)	Various water sources across SSA	~50.7% MDR in *E. coli* water isolates	Resistance to ciprofloxacin (13.1%), ampicillin (69.4%), others

Table 2. *Recent studies reporting multidrug-resistant (MDR) and extended-spectrum β-lactamase (ESBL)-producing Escherichia coli in water sources in SSA (32).*

Note: blaCTX-M, blaTEM, and blaSHV are genes encoding β-lactamase enzymes that confer resistance to β-lactam antibiotics, including penicillins and cephalosporins.

Healthcare-associated transmission is another critical pathway. Many health facilities in SSA lack basic WASH infrastructure, including clean running water, flushable toilets, soap, and handwashing stations (35). UNICEF (2021) reports that only 51% of healthcare facilities in the region have access to basic water services, and just 23% have basic sanitation (19). This compromises infection prevention and control (IPC) efforts and increases the incidence of healthcare-associated infections (HAIs), which often necessitate antibiotic treatment (26). Furthermore, the overburdened health systems and poor hygiene practices among healthcare workers, due to inadequate facilities, amplify the spread of multidrug-resistant organisms (MDROs) within clinical environments (25). According to WHO/UNICEF JMP (2023), access to basic drinking water, sanitation, and hygiene remains highly variable across SSA (9). Figure 2 visualizes these disparities, highlighting countries where sanitation and hygiene coverage lag far behind water access.

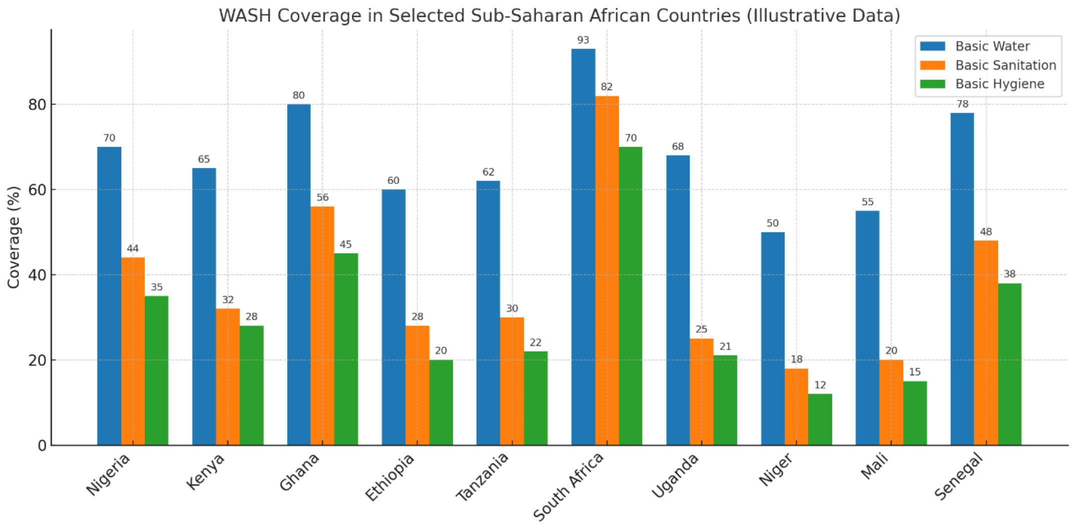

Figure 2. *WASH coverage in selected SSAn countries, showing the percentage of the population with access to basic drinking water, basic sanitation, and basic hygiene facilities (illustrative data recreated from WHO/UNICEF JMP 2023) (9).*

Another underappreciated transmission route is related to agricultural practices. Livestock production in SSA frequently relies on antibiotics, not only for treatment but also for growth promotion and prophylaxis (14). However, farm environments often lack proper sanitation infrastructure. Animal waste, containing unmetabolized antibiotics and resistant bacteria, is commonly used untreated as fertilizer or allowed to contaminate nearby water sources (24, 35). A study by Dickin et al. (2018) emphasized that livestock produce an estimated 80% of global fecal matter, yet are largely excluded from conventional WASH policies (36). This omission creates a major reservoir of resistance that can affect both animals and humans, particularly in farming communities that share water sources and physical spaces with their animals (37).

Foodborne transmission of resistant organisms is also a concern. Poor hygiene in food preparation areas, particularly in informal markets common across the SSA region, allows resistant bacteria to persist and multiply. Contaminated meat, vegetables irrigated with untreated wastewater, and unwashed utensils contribute to the cycle (10, 38). According to Christiana Cudjoe et al. (2022), E. coli resistant to third-generation cephalosporins was isolated from fresh produce and meat in markets in Kenya and Ghana, likely linked to contaminated water used during processing (10). These foodborne pathogens can cause infections that are more difficult and costly to treat, particularly in children and immunocompromised individuals (24).

Additionally, improper disposal of unused or expired antibiotics exacerbates environmental contamination. In many SSA countries, there are no formal systems for pharmaceutical waste disposal. Households often flush leftover antibiotics down the toilet or discard them with regular trash, which eventually enters landfill sites or water systems (12, 39). Pharmaceutical manufacturing waste, particularly in unregulated industrial zones, has also been implicated as a contributor to environmental AMR hotspots (25). This ecological contamination creates opportunities for resistance genes to circulate among environmental bacteria, from where they may be acquired by human or animal pathogens (27, 38).

One Health Approach

The One Health concept recognizes that human, animal, and environmental health are interconnected. As the WHO notes, One Health "is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems (25). In practice, this means addressing diseases and risk factors across sectors, for example, by improving animal health and habitat alongside human health measures (25). One Health is especially critical for AMR and WASH, because drug-resistant pathogens and antibiotic residues move freely through humans, livestock, food, and the environment (40).

Studies highlight that up to 75% of emerging human infections are zoonotic and that environmental reservoirs (such as contaminated water and soil) amplify AMR spread (11, 41). For instance, WHO emphasizes that resistant organisms "can spread quickly" via animals, food, and water, making AMR control a "multifaceted" problem that requires collaboration across human, animal, and environmental sectors (42). Likewise, a recent review argues that integrated One Health–WASH strategies can improve on-farm biosecurity while also reducing infection pressures on human communities (6, 39).

One Health also implies including WASH in AMR prevention, ensuring safe WASH for both people and livestock. Inadequate sanitation in any domain can drive disease. For example, the WHO points out that antimicrobial residues and resistant microbes are "common and widespread" in wastewater from both human and animal sources, and that "universal access to sanitation, hygiene and safe water" is a priority to reduce infections that would otherwise require treatment (11, 25). In One Health terms, this means targeting contamination at source, improving latrines, water supplies, and waste treatment in both communities and farms, to break cycles of transmission (11, 36, 40). As Dickin et al. (2025) explain, WASH programs typically focus on human feces while overlooking animal waste, yet livestock produce ~80% of the global fecal load (43). A true One Health WASH framework deliberately addresses animal husbandry and environmental sanitation alongside human hygiene (36). One Health approaches to AMR mitigation integrate WASH interventions across human, animal, and environmental sectors (21, 28). Figure 2 illustrates these intervention domains, showing both potential AMR flow and points where WASH measures can disrupt transmission pathways.

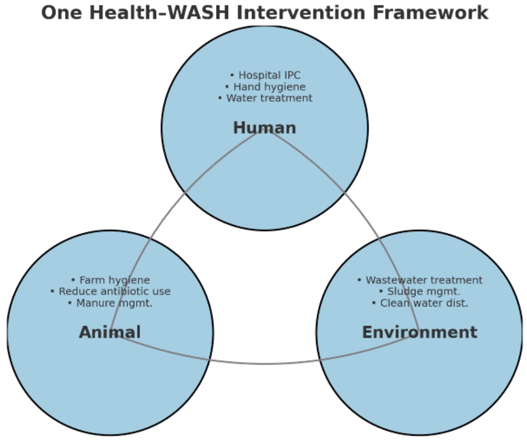

Figure 3. *One Health–WASH intervention framework showing key points for antimicrobial resistance mitigation across human, animal, and environmental domains (21, 28). Arrows depict potential AMR flow between sectors and intervention breakpoints.*

In SSA, several African efforts illustrate One Health integration. In Uganda, a recent USAID-supported program explicitly adopted a One Health approach to strengthen the AMR response (4). Working with health, animal, and environmental sectors, it coordinated improvements in infection control (IPC), WASH, and antibiotic stewardship across ministries (4). This intervention trained health workers in facility hygiene, adapted animal-health biosecurity tools, and even brought WASH facility improvement checklists into routine practice in clinics and farms (4). The authors report that best practices in IPC and WASH were shared across at least five partner organizations, and baseline assessments of IPC/WASH were conducted by hundreds of healthcare and animal-health staff (4). In Rwanda, researchers conducted a One Health WASH evaluation of four rural communities, surveying both households and livestock. They found that animals had significantly poorer access to clean water and sanitation than people, and identified one community as having critically low WASH coverage overall (44). They conclude that "multi-sector collaboration among public health, water authorities, and local leaders" is urgently needed so all residents – human and animal – can access safe water (44). Finally, multi-country research networks are forming, for example, a transdisciplinary SEI OneHealth–WASH project that links Burkina Faso, Kenya, and Mozambique to exchange knowledge on reducing zoonoses and AMR through integrated water/sanitation measures (45). Altogether, these initiatives show how One Health thinking, coordinating health, veterinary, agriculture, and WASH sectors, is being translated into practice, even though much more scale-up is needed.

Policy and Implementation Challenges

Despite the rationale for linking WASH and AMR, policy gaps remain. In many SSA countries, WASH and AMR are managed by separate ministries with weak integration. WHO observes that WASH and wastewater actors are still "under-represented" on AMR multi-stakeholder platforms and in national action plans (20). In practice, sanitation ministries often have their targets (SDG 6) while health ministries drive AMR NAPs, with little overlap (20). Few countries explicitly mention WASH in AMR policy documents, and vice versa. This siloing means opportunities are missed. For instance, a national sanitation strategy may not consider the risk of spreading AMR through open sewage, and an AMR plan may focus on drug regulations without supporting community sanitation (16). In effect, both policy streams may contain gaps that leave environmental reservoirs of resistance unaddressed.

Multisector coordination and funding are major obstacles. Coordination bodies and committees often lack authority, clear terms of reference, or financial support (16). A regional survey found that political commitment to AMR in many African countries is low and that governance and regulatory frameworks are weak (16, 20). Only a handful of countries have dedicated budgets for AMR programs, with one report noting just 6 of 31 African countries surveyed had allocated state funding for antimicrobial stewardship, unlike richer nations that typically earmark health budgets for such work (46). This funding gap undermines even well-designed plans (40, 46). Similarly, WASH programs often depend on external aid or local government budgets that are already stretched. Without joint financing mechanisms (e.g., a One Health fund or pooled WASH/health grants), it is difficult to coordinate infrastructure projects and AMR surveillance across sectors (39). Competing priorities – such as malaria control or urban water supply – can draw attention and funds away from integrated AMR-WASH initiatives (20, 46).

At the local level, multiple barriers slow implementation. Infrastructure deficits are severe. Most rural communities still lack reliable piped water or sanitation networks. For instance, only about half of health facilities in Africa have a basic water supply, and under a quarter have proper sanitation (14, 35). Where pipes do exist, intermittent supply, broken taps, or lack of safe drainage can render facilities unhygienic (41). Even when infrastructure is in place, governance issues can impede use. poor maintenance, corruption, or unclear ownership (who is responsible for repairs) are common (1, 12). Water quality monitoring is often insufficient, so communities may not trust or treat "safe" water. Social and cultural factors also matter. Low awareness of AMR and hygiene means people may continue practices (open defecation, stacking animal pens near homes, or buying antibiotics without a prescription) that undermine health (3, 26, 35). Education campaigns are weak or absent in many areas, especially in remote villages (23). As one review observed, low awareness and training, coupled with economic pressures, drive rampant antimicrobial misuse and poor hygiene practices in African settings (1).

Examples from SSA countries illustrate this uneven progress. Rwanda has been recognized for advancing a strong One Health governance framework, with high-level coordination committees linking human, animal, and environmental health sectors. This has enabled WASH issues (such as safe manure management and water safety plans) to be integrated into its national AMR strategy (47). In Uganda, the National Action Plan on AMR (2018–2023) explicitly included WASH and infection prevention targets in healthcare facilities, yet implementation has faced funding shortages and limited surveillance capacity, slowing its impact (48). In contrast, Nigeria demonstrates persistent challenges, where, although a National Action Plan on AMR exists, enforcement remains weak. Poor inter-ministerial coordination and minimal budgetary allocation have limited integration of WASH into AMR policy, leaving major environmental reservoirs unaddressed (8).

Opportunities for integration exist, however. Global initiatives and donor programs are beginning to encourage One Health planning. For example, the WHO/FAO/OIE "technical brief" explicitly urges countries to bring WASH interventions into AMR national plans (49). African governments can leverage these frameworks and partner support to bridge policy divides. Members of the WHO-FAO-WOAH quadripartite already work together on multisectoral collaboration and training in AMR, providing a platform to add WASH expertise. Linking AMR with other national goals also helps, such as incorporating sanitation improvements into pandemic preparedness or UHC strategies, which can attract funding that benefits both AMR and broader health (49). In some settings, AMR and WASH plans can piggyback on successful programs, such as adding antibiotic stewardship components to cholera response teams or using community health workers to teach hygiene and prudent antibiotic use simultaneously (20, 49).

Finally, the rising awareness from the COVID-19 response may catalyze action. The emphasis on handwashing and infection prevention during the pandemic shows that hygiene behavior can change rapidly with political will and resources. If African leaders build on this momentum – explicitly linking clean water and sanitation to antibiotic resistance – they may unlock new investment. Climate resilience funding (for drought-proof water supplies) and antimicrobial-pharmaceutical regulations are other entry points, demanding safe effluent treatment from factories, which benefits both the environment and AMR control (22, 41).

Strategies and Recommendations

Effective AMR prevention requires **practical WASH improvements** at all levels, ideally designed with community engagement and cross-sector buy-in. Key strategies include:

- **Expand WASH access:** Rapidly increasing safe water supply and sanitation are fundamental. In communities, this means building or rehabilitating wells, boreholes, protected springs, and latrines, with attention to underserved rural and peri-urban areas. In schools, markets, and healthcare facilities, ensuring basic water, soap, and toilets is vital. WHO notes that universal access to sanitation, hygiene, and safe water "is a priority measure to prevent many infections that would otherwise be treated with antimicrobials." (25). Coverage gaps are stark in SSA (for example, only ~51% of health facilities have basic water and 22% basic sanitation, so investment in infrastructure is urgent (50). Donors and governments should align funding (e.g., WASH trusts or SDG 6 investments) to extend piped water, community handpumps, and latrines, and promote household water treatment (4).
- **Promote community-led hygiene.** Empowering local leaders and households to adopt hygienic practices is cost-effective. Community-led total sanitation (CLTS) campaigns, water-user committees, and Village Health Teams can spread handwashing, safe water handling, and waste

disposal messages. Engaging women and schools, especially primary and secondary schools, is particularly impactful. Women often manage family hygiene and water, and school-based programs can model handwashing for children. Evidence shows that basic hand hygiene alone can cut diarrhea by up to 30% (49). Hygiene promotion should be integrated into existing outreach (e.g., immunization drives or HIV/TB programs) and leverage mass media or mHealth reminders. Crucially, these programs should incorporate AMR education, explaining that preventing infection (via clean water, soap, vaccines, etc.) is the first line of defense against antibiotic-resistant disease.

- **WASH in healthcare facilities (HCFs) and farms.** Strengthening infection prevention in HCFs and on farms is a priority. All clinics and hospitals need functioning water points, sanitation blocks, and waste disposal systems. Training all health workers in handwashing and safe injection/cleaning procedures reduces hospital-acquired infections and antibiotic use. Likewise, on farms and in animal markets, basic biosecurity and sanitation (e.g., treated livestock water troughs, manure pits, fenced animal enclosures) are needed. Interventions such as corralling poultry, providing separate animal troughs, or introducing "clean feet" mats for farm entry have been shown to lower zoonotic disease risks (24). By improving farm hygiene (clean water for animals, proper burial/composting of animal waste, and vaccinating livestock), antibiotic use in animals can be reduced, thereby lessening environmental AMR spread.
- **Cross-sector surveillance and coordination.** Effective AMR monitoring in SSA requires surveillance systems that integrate human, animal, and environmental health data. In practice, this means combining hospital-based AMR reporting with environmental and veterinary monitoring to detect emerging threats early. The WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) provides a global platform for standardizing human health AMR data and is increasingly being adopted in SSA (25). Complementary initiatives such as the WHO Tricycle Project specifically track ESBL-producing E. coli across humans, food, and the environment, making it an ideal model for integrated One Health surveillance (33). In the animal health sector, the FAO Assessment Tool for Laboratories and AMR Surveillance Systems (ATLASS) helps countries evaluate and strengthen veterinary AMR monitoring capacity (15). Linking these platforms, along with periodic testing of water sources, food products, and farm soils for resistant bacteria, would create a more robust and unified early warning system. At the governance level, establishing One Health coordination committees, including representatives from health, agriculture, environment, water, and local communities, can ensure data sharing, harmonized regulations (e.g., on waste discharge), and joint outbreak response training, avoiding siloed interventions and maximizing impact.
- **Fully integrate WASH and IPC into AMR National Action Plans (NAPs) and implementation frameworks.** Countries should fully integrate WASH(WASH) and Infection Prevention and Control (IPC) into their AMR National Action Plans (NAPs) by setting measurable targets for WASH coverage in health facilities and communities, and allocating dedicated budget lines for infrastructure upgrades and hygiene promotion. Ministries responsible for water, sanitation, and the environment must be actively involved in AMR governance platforms to ensure a truly multisectoral response. Aligning agricultural practices with One Health goals, such as through safe manure and wastewater management, will further strengthen efforts to curb AMR at the human-animal-environment interface.

Table 3. Prioritized Recommendations for Strengthening WASH and AMR Mitigation in SSA

Timeframe	Key Recommendation	Responsible Actors	Feasibility & Notes
Short-term (1–2 years)	Expand community access to safe water and sanitation through boreholes, wells, latrines, and handpumps	Governments, NGOs, local communities	Feasible with targeted donor/government funding; aligns with SDG 6
	Promote community-led hygiene (CLTS, school programs, women-led initiatives) with AMR education	Local leaders, schools, NGOs, and health ministries	Low-cost, high-impact; evidence shows hand hygiene reduces diarrhea by ~30%
	Basic WASH upgrades in healthcare facilities (handwashing points, waste disposal, IPC training)	Health ministries, hospital administrators, NGOs	Highly feasible, requires modest investment
Medium-term (3–5 years)	Improve farm hygiene and biosecurity (clean animal water troughs, manure pits, fenced enclosures)	Ministries of agriculture, farmers' associations	Feasible with training and subsidies; reduces antibiotic use in livestock
	Establish and strengthen One Health surveillance systems (GLASS, Tricycle, ATLASS)	Ministries of health/agriculture/environment, WHO/FAO/WOAH	Moderate feasibility; requires intersectoral coordination and capacity building
	Integrate WASH and IPC targets into AMR National Action Plans (NAPs)	National governments, policymakers, and donors	Requires political commitment; improves accountability
Long-term (5+ years)	Large-scale infrastructure investments in piped water, wastewater treatment, and urban sanitation	National governments, donors, and the private sector	High cost but critical for sustainability
	Institutionalize One Health coordination committees across sectors	Governments, development partners, and communities	Sustainable once established; enhances cross-sector policy alignment
	Align agricultural waste management with One Health goals (safe manure, wastewater treatment)	Ministries of agriculture, environment, and water	Resource-intensive but essential for systemic AMR prevention

Table 3. *Prioritized recommendations for policymakers to address WASH-related AMR risks in sub-Saharan Africa. Recommendations are grouped into short-, medium-, and long-term actions, with corresponding responsible actors and feasibility considerations.*

Conclusion

Antimicrobial resistance (AMR) poses an escalating threat to public health, economic stability, and environmental sustainability in SSA. Inadequate WASH infrastructure and practices act as both direct and indirect drivers of this crisis by facilitating the spread of resistant pathogens, increasing the frequency of infections requiring antimicrobial treatment, and enabling the environmental persistence and transmission of resistance genes. Addressing AMR without tackling these foundational WASH deficiencies is not only ineffective but unsustainable.

This review has illustrated the critical intersections between AMR and WASH within a One Health framework, underscoring the need for cross-sector collaboration and integrated action. From community to national levels, practical interventions, such as improving access to clean water and sanitation, promoting hygiene behaviors, and embedding AMR awareness into public health education, can significantly reduce resistance rates and curb unnecessary antibiotic use. These efforts must be woven into broader health systems and aligned with initiatives in food safety, veterinary services, and environmental protection.

Although significant policy gaps and implementation challenges persist, including fragmented governance, inadequate funding, and weak infrastructure, promising models exist. Fully integrating WASH into AMR National Action Plans (NAPs), expanding environmental surveillance, and aligning AMR goals with broader development agendas such as Universal Health Coverage (UHC) and the Sustainable Development Goals (SDGs) can unlock meaningful progress.

In sum, combating antimicrobial resistance in Africa requires more than access to better antibiotics; it demands a transformation of the environments in which people live, work, and seek care. Expanding equitable access to WASH remains one of the most effective and sustainable strategies to disrupt the transmission of resistant infections and safeguard antibiotic efficacy. A One Health–aligned, WASH-centered approach to AMR is not only timely but also essential for long-term regional resilience.

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